United States Department of Agriculture

Forest Service

Southwestern Region

Forestry and Forest Health

R3-01-02

Effects of Three Prescribed Fires on Dwarf Mistletoe Infection in Southwestern Ponderosa Pine

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Acknowledgements

Brian Geils, Mary Lou Fairweather, Bob Mathiasen, and Deb Allen-Reid reviewed an earlier version of this report, and each provided many comments and suggestions that were used to improve the final version. Brian also encouraged and helped with the statistical analyses that were added. Jeff Hogg's assistance with the graphics, especially in construction of Figure 6, is acknowledged and greatly appreciated. Andy Serrano and district crews are commended for planning and implementing these (and several other) successful prescribed fires on the Española Ranger District.

Authors Note *(March 2005):* Making this 2001 report available online has allowed us to make some minor editorial changes and correct a few grammatical errors that appeared in the original report. The abstract has been modified to better summarize key findings.

Dan Ryerson (Forest Health Protection) is acknowledged for his able assistance in preparing the online version.

Cover Photo: The March 1996 Blanco fire, one of three prescribed fires described in this report.

Abstract

Results are presented from three prescribed fires (underburns) conducted in 1995, 1996, and 1997 on the Santa Fe National Forest, Española Ranger District, in northern New Mexico. Average crown scorch on six monitoring plots (n=877 ponderosa pine sample trees) ranged from 28 to 77 percent; tree mortality three years after the fires ranged from 9 to 36 percent. About 25 percent of the ponderosa pines that received 100% crown (needle) scorch survived. Infection levels (DMRs) were reduced on all plots, with reductions ranging from 0.3 to 1.6, compared to projected values, three to four years after the fires. In two of the fires (timber litter models), heavily infected trees had higher mortality rates than other trees, and reductions in plot DMR increased with increasing average scorch. In the third fire (a timber slash model), reductions in plot DMR were less (relative to scorch) than in the other fires; here a recent thinning had already reduced stand DMR considerably, limiting potential for further reduction. Dwarf mistletoe infection reduced survival of fire-scorched trees, although not to the extent reported by Harrington and Hawksworth (1990); the effect was pronounced only for DMR 6 trees with 90 to 100 percent crown scorch. Scorch pruning contributed toward the reduction in average DMR on each of these six plots; DMRs were reduced on about 30 percent of the surviving infected trees. Monitoring will continue on these plots and others established in more recent burns to better quantify the effects of fire on dwarf mistletoe.

Introduction

Better understanding and awareness of natural fire regimes in the Southwest have stimulated interest in – and increased use of – prescribed burning. The severe wildfires of recent years, particularly in 2000, have focused attention on the need for prudent treatments to reduce fire hazard. From a mistletoe control perspective, prescribed underburning may provide an alternative to more traditional management approaches that have become controversial (Harrington and Hawksworth 1990, Conklin 2000).

Although fire has long been considered an important natural control of dwarf mistletoe (Roth 1953, Hawksworth 1961), ideas about using prescribed fire to manage the disease have changed considerably in recent years. Previously, most attention focused on use of intense, stand replacing fire to eliminate the parasite prior to regeneration of a site (Alexander and Hawksworth 1975). Only more recently have less intense fires (underburns) received attention as a potential tool for managing dwarf mistletoe (Koonce and Roth 1980, Harrington and Hawksworth 1990).

Two previous studies have been conducted on the effects of underburing on dwarf mistletoe: Koonce and Roth (1980) in central Oregon, and Harrington and Hawksworth (1990) at the Grand Canyon. Both studies reported reductions in stand infection levels following prescribed understory burning. However, both studies involved relatively small samples of scorched trees, and conclusions were made only a year or so after the fires. Our objective has been to follow a larger sample of scorched trees over a longer period of time to better quantify relationships between underburning and dwarf-mistletoe-infected ponderosa pine in the Southwest. This report describes case histories of operational prescribed burns.

Site Descriptions

These three fires were conducted on the Española Ranger District of the Santa Fe National Forest, in the eastern portion of the Jemez Mountains. Two of the fires – the Road 145 fire and the Blanco fire – were near Clara Peak, about ten miles north of Los Alamos and ten miles west of Española. The third fire – the Alamitos Mesa fire – was about three miles north of Los Alamos.

The Road 145 and Blanco fires were in pole-sized stands of ponderosa pine that had been “sanitation thinned” to 10-12 foot spacing (around 300 trees per acre) about 12 years earlier. Most dominant and codominant trees were 50 to 70 years old and 30 to 45 feet tall. These stands are ponderosa pine/gambel oak type, on west facing slopes of ten to 30 percent, at approximately 7,900 feet in elevation. Soils are of basaltic origin, with site quality in the low to moderate range for Southwestern ponderosa pine.

Alamitos Mesa was heavily thinned, mostly from below, in the fall of 1996, one year before the burn. The thinning had reduced densities from in excess of 300 trees per acre to about 50 trees per acre. This stand was also predominantly pole-sized ponderosa pine, but contained a scattering of larger mature pine, most of which were retained during the mechanical treatment. The stand is a pine/grassland community on a gentle east-facing slope at about 7,600 feet. Soils here are derived from pumice, with site quality also in the low to moderate range.

Sampling Methods

Prior to each fire, we established rectangular plots in areas with fairly uniform stand structures and where a majority of trees were visibly infected. All live ponderosa pines >1 inch in diameter at breast height (dbh) were tagged, measured for dbh, and rated for dwarf mistletoe infection using the standard 6-class system (Hawksworth 1977).

Three plots were established in the Road 145 area in June 1994; the stand was burned in October 1995. A single previously established (1991) plot was used to monitor the effects of the Blanco fire; this plot was remeasured a few days before the March 1996 fire. Two plots were established on Alamitos Mesa in October 1997, one week before the burn. A total sample of 877 trees was used to monitor the effects of the three fires (Table 1).

Table 1. Plots at time of establishment.

Plot	Size (Ac.)	No. Live Trees	Average DBH
Road 145-1	0.5	161	7.5
Road 145-2	0.4	123	7.5
Road 145-3	0.7	165	8.1
Blanco	0.5	162	6.5
Alamitos-1	5.0	186	11.1
Alamitos-2	2.0	80	12.7

Crown scorch ratings for each sample tree were made a few months after the fires, *prior to the flush of new growth*. These were estimates, to the nearest 10 percent, of the proportion (length) of the live crown in which the needles had scorched. Each tree was observed from several angles; some judgment was needed for trees with irregular scorch patterns. To better account for the importance of the uppermost crown, heavily scorched trees

with at least one whorl of largely unscorched needles at the apex usually received ratings of 90 percent rather than 100 percent, even though more than 95 percent of the crown length (and 98 percent or more of the crown volume) may have been affected.

Dwarf mistletoe ratings (DMR's) were first retaken three years after the fires. On the Road 145 plots, ratings were also done about eight months later (five years after plot establishment) so that intensification could be compared more directly with a set of similar unburned plots.[3] Tree survival/mortality was checked two, three, and five years after the fire on the Road 145 plots; three years after the fire on the Blanco plot; and one, two, and three years after the fire on the Alamitos Mesa plots. Dead trees were examined for signs of successful bark beetle attack.

No attempt was made to estimate damage to the bole or roots. Although these can be important factors affecting the survival of fire-damaged trees, they can be difficult to quantify. Moreover, severe bole char is usually needed to cause significant cambial damage and subsequent mortality. Crown scorch is usually a good indicator of fire intensity, and is particularly relevant to dwarf mistletoe, which inhabits the crown. On most trees, estimating crown scorch is easy and yields good agreement between observers (Ryan 1982). The proportion of the *crown killed* is a better predictor of tree mortality (Wagener 1961, Ryan 1982), but cannot be determined as quickly and easily as needle scorch.

The primary objective in monitoring these fires was to relate average crown scorch to reductions in mistletoe (plot DMR). Although our methods do not involve random or systematic samples, they were expected to provide reasonable estimates of the effects of fire on mistletoe where it occurred in these stands and where similar fire intensities (scorch) were achieved. Chi-square tests of independence ($p < 0.01$) were used to examine scorch, DMR, and survival relations among individual trees.

[3] These unburned plots are described in Appendix A.

Fire Treatments

Each fire was roughly 200 acres in size and hand-ignited. Burning was completed within a few hours in each area. The Road 145 fire (October 1995) and Blanco fire (March 1996) were intended to reduce natural fuel accumulations and provide some tree thinning, while the Alamitos fire (October 1997) was primarily intended as a slash reduction burn. Mistletoe reduction was an objective, although not the primary objective, in each burn.[4]

The Road 145 and Blanco areas were typical National Fire Behavior Prediction System (NFBPS) 9 / timber litter models (Anderson 1982). Ground fuels were mostly needle accumulations, with occasional concentrations of old thinning slash. Oak thickets and scattered pinyon and juniper provided some ladder fuels.

Burning conditions were similar in both of these fires. Fall through spring of 1995-1996 was extremely dry, with only a few inches of snowfall in the project areas that winter. The snow had been gone for several weeks before the March fire. One-hour fuel moistures were between three and seven percent, air temperatures were about 70 degrees F, and mid-flame wind speeds two to six miles per hour.

Ignition patterns were mostly strip-head fire. Some ignitions were made just below the study plots to insure adequate fire intensities within the plots, although the intensities achieved were fairly consistent throughout most of the stands. Flame lengths generally ranged from one to four feet, with some crowning in the pinyon and juniper. Limited crowning also occurred in the pine in a few areas, including a small portion of the Road 145 #2 and Blanco plots.

The Alamitos area was a NFBPS 12 / timber slash model (Anderson 1982). After thinning, the area had been opened to firewood gathering, removing the majority of the larger down material, but leaving small stems and branches scattered throughout. Crews were sent in before the burn to break up heavy concentrations of fuel and create a more uniform fuel bed; however, the large amount of slash, the size of the area, and time constraints limited how effectively this was accomplished. A light snow had fallen the week before the burn was scheduled and a few patches remained the day of the burn.

One-hour fuel moistures were eight to 12 percent, air temperatures 45 to 50 degrees, and wind speeds eight to ten miles per hour. The ignition pattern was dispersed, with crews instructed to stay 20 to 30 feet apart as they moved across the unit and lit at six to eight foot intervals. Flame lengths generally ranged from two to eight feet, but despite the absence of ladder fuels and a few patches of snow on the ground, sporadic crowning did occur.

[4] As can best be determined, there was no attempt to kill or prune individual trees during these fires. Except as noted in the text, mistletoe reduction was really just a potential benefit resulting from natural and chance distributions of the parasite and the scorch.

Results and Discussion

On the Road 145 and Blanco plots most trees (81 percent) less than 4" dbh were killed by the fires, while only 22 percent of the larger trees died. Because of this difference, the smaller trees (n=64) are not included in the results presented below. Removing them from the analyses allows a better indication of some the effects of the fires, although it has only a minimal effect on plot DMRs, both initially and over time. All trees on the Alamitos Mesa plots were over 4" dbh.

Crown Scorch

Figure 1 displays the proportion of sample trees in each scorch class on each plot. Average scorch ranged from 28 to 77 percent on the six plots. As can be seen, a given average scorch contained a wide range of scorch on individual trees. Note that the great majority of crown scorch on all six plots was a result of heat rather than direct combustion, although the fires did “crown out” in a few trees on some of the plots.

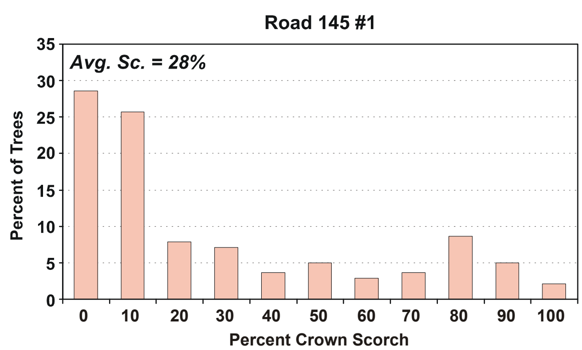
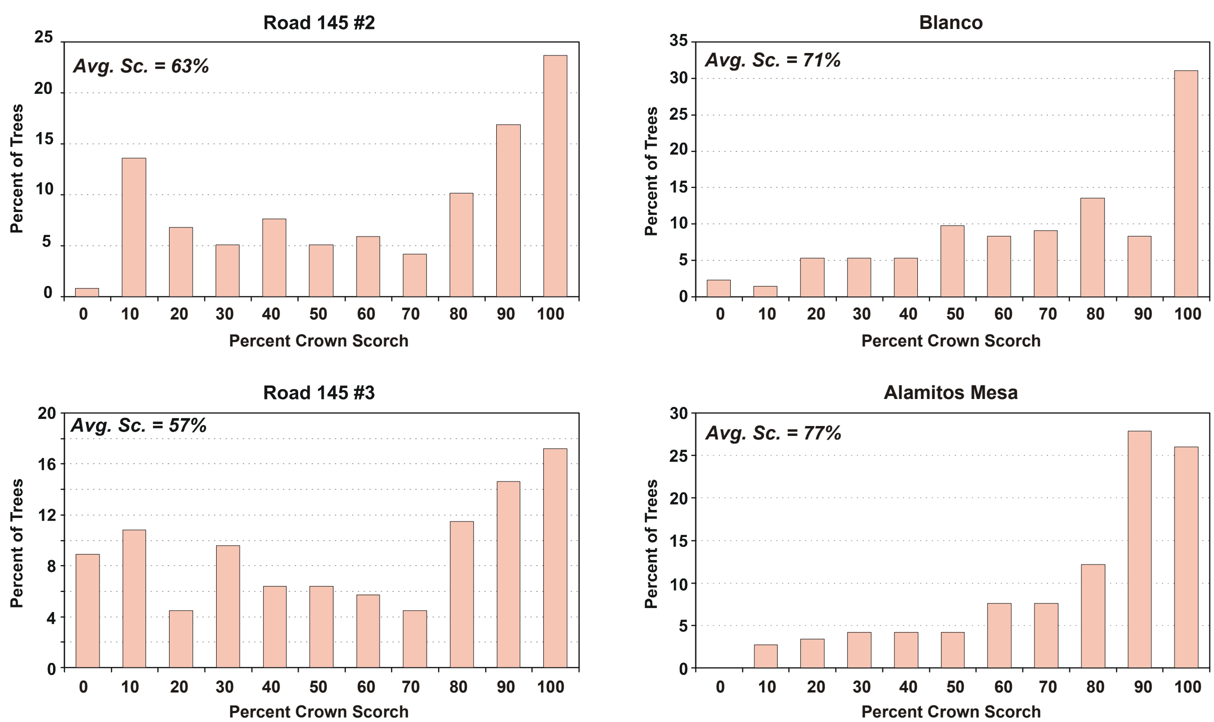


Figure 1. Proportion of trees in each scorch class, by plot.

The Alamitos Mesa plots are combined here since they both had the same average scorch and because one plot contained a much larger sample than the other (Table 1).



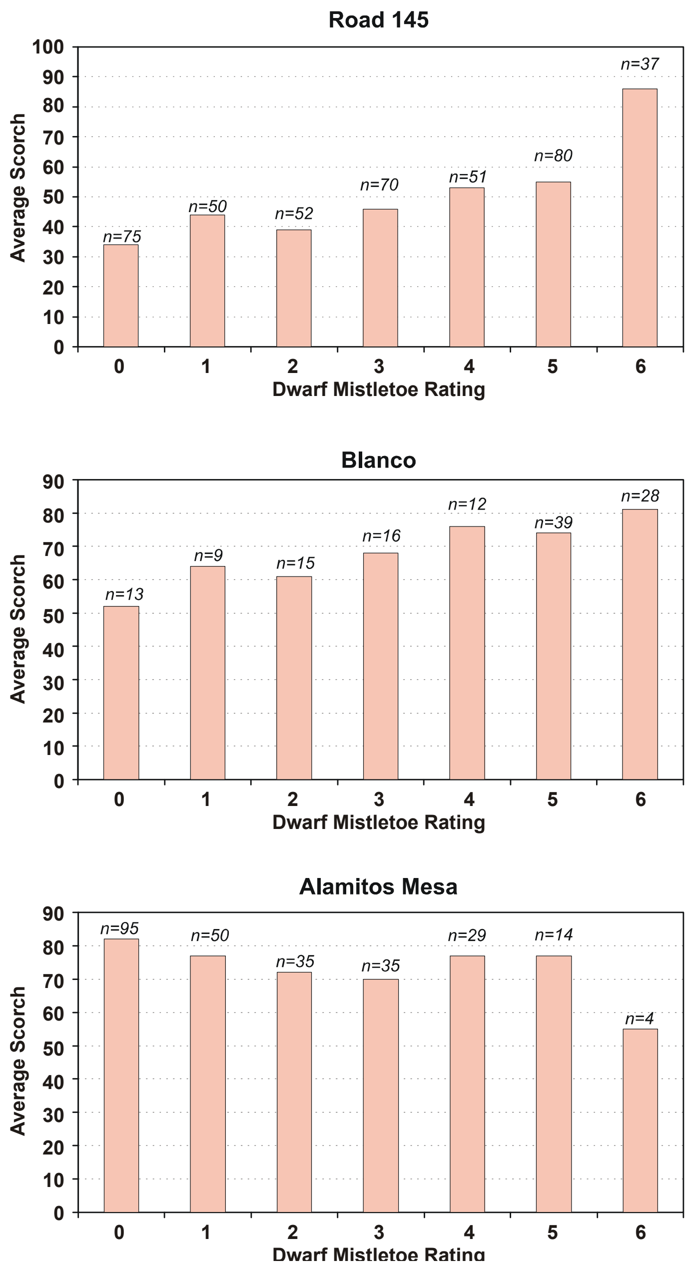


Figure 2. Average scorch for trees in each DMR class.

Average crown scorch generally increased with increasing tree DMR in the Road 145 and Blanco fires (Figure 2). (Although the Road 145 plots have been combined in Figure 2, the upward trend occurred on each of the three plots.) A similar pattern had been reported by Harrington and Hawksworth (1990). This trend may be due to at least two factors: 1) the branching patterns of infected vs. uninfected trees and 2) greater fuel loading around infected trees. This trend did not occur on the Alamitos Mesa plots, where scorch seemed largely determined by the amount of thinning slash on the ground.

Tree Mortality

Figure 3 shows the proportion of trees in each scorch class that were dead after three years. On the Road 145 plots, considerable mortality (24 trees, about 28 percent of the total mortality) occurred in the low to moderate (0-70 percent) scorch classes, almost all of it from attack by *Ips* bark beetles. On the Blanco and Alamitos plots, mortality was essentially limited to the high (80-100 percent) scorch classes (the single exception being a lightly scorched DMR 6 tree on the Blanco plot). Bark beetle activity was low on the Blanco and Alamitos plots, with attacks occurring only on some of the heavily scorched trees.

On the Alamitos Mesa plots, where mortality was checked annually, most of it (76 trees) occurred the first year, with the remainder (5 trees) in year two; none occurred in year three despite a severe drought. Mortality was not tallied on the Blanco plot until three years after the fire, but based on the condition of the dead trees at that time, probably all of it occurred in years one and two.

The bark beetle activity in the Road 145 area extended mortality into year three (on two of the three plots; a total of eight trees, or about ten percent of the total mortality on the three plots). Only two additional trees on the Road 145 plots died between years three and five, which is well within a mortality rate that could be expected for an unburned stand of this condition.

In each of the burned areas, many heavily scorched trees recovered. Approximately 70 to 90 percent of trees in the 90 percent scorch class survived, as did 20 to 30 percent of those in the 100 percent scorch class (Figure 3). Since the 100 percent scorch class included a few trees in which the fires had crowned, the survival rate of those that were only *heat scorched* exceeded 30 percent. Other studies have reported remarkable recovery of heavily scorched ponderosa pine (Dieterich 1979, Harrington 1987).[5]

Survival tended to increase with increasing size (dbh) on each of the six plots. On the combined Road 145 and Blanco plots, 87 percent of trees 9" dbh and larger survived (three years after burning), while 75 percent of those 4 to 8.9" survived (and only 19 percent of those under 4", as mentioned earlier). On Alamitos Mesa, 77 percent of trees 12" dbh and larger survived, while 64 percent of the smaller trees survived.

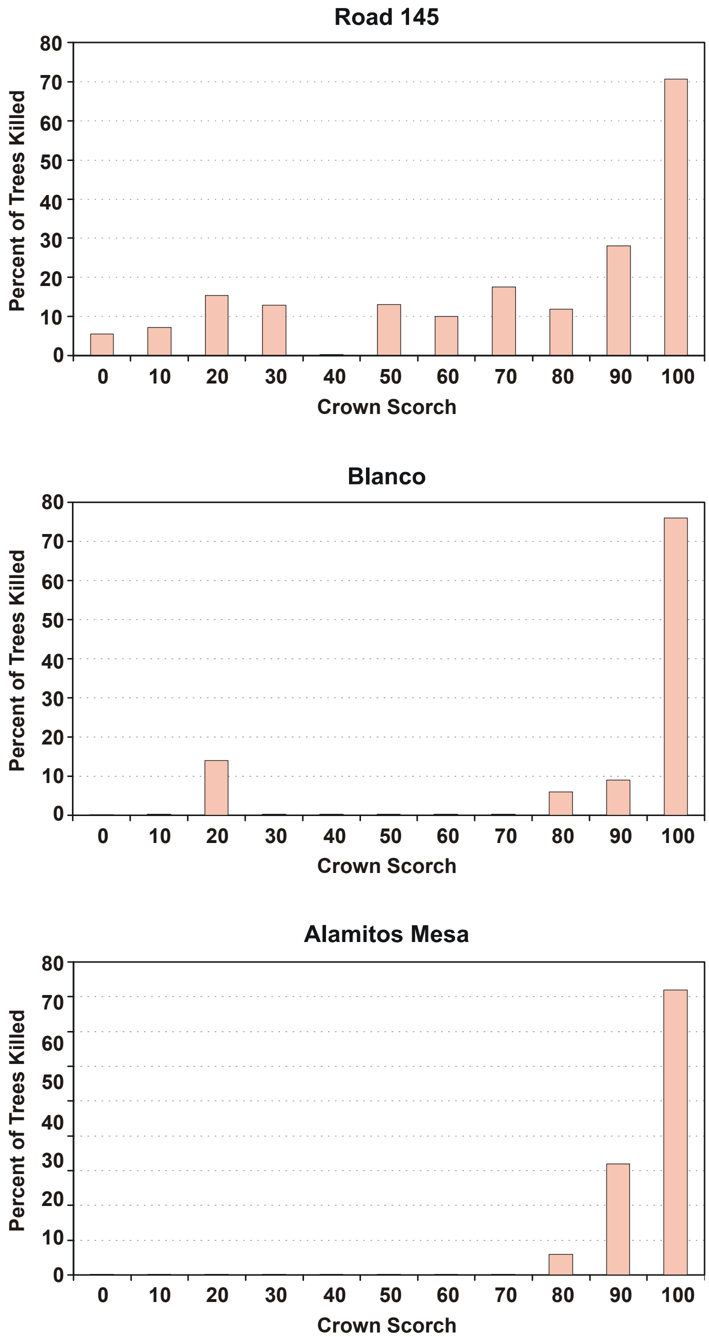


Figure 3. Proportion of trees in each scorch class that were dead three years after the fire.

[5] Good recovery of scorched ponderosa pine probably occurs more often than not, at least in pole and small sawtimber-size stands burned during the dormant season. A common misconception about the survivability of fire-damaged trees arises from confusion between the proportion of the crown (needles) scorched and the proportion of the crown killed. The available literature does not always adequately distinguish between the two.

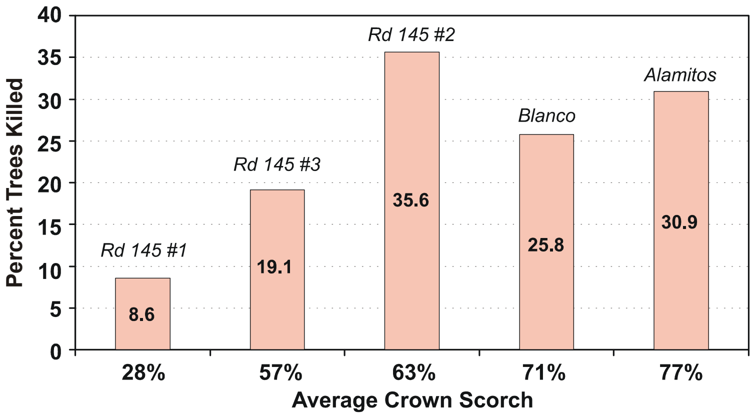


Figure 4. Proportion of trees killed over 3 years on each plot versus average crown scorch.

Figure 4 summarizes average crown scorch and tree mortality on the plots. Here again, the Alamitos plots are combined since they had almost identical scorch. Note that bark beetle activity elevated mortality on each of the Road 145 plots. The high mortality on the Road 145 #2 plot was also a function of its high infection level. Survival on the Alamitos plots (69 percent) was better than we had initially expected, given that over half the trees received 90 to 100 percent crown scorch (Figure 1).

Tree DMR and Mortality

Heavily infected trees (DMR 5 and 6's) had consistently higher mortality rates than other trees on the Road 145 and Blanco plots (Table 2). In these areas, 28 percent of the DMR 5 trees and 71 percent of the DMR 6 trees were dead after three years, while only 11 percent of the other trees died. Tree DMR/mortality relations in all three fires are illustrated in Figure 5. A more or less random pattern occurred on Alamitos Mesa. (The small sample of DMR 6 trees on Alamitos Mesa (n=4) affected these results, but scorch and mortality here were largely determined by slash from the recent thinning.) However, the mortality rate for infected trees (in total) did exceed the rate for uninfected trees on Alamitos Mesa (35 percent vs. 23 percent).

Table 2. Proportion of trees killed and mortality ranking by mistletoe severity classes (DMR) on Road 145 and Blanco plots; mortality determined three years after fire.

	DMR									
Plot	**0**		**1-2**		**3-4**		**5**		**6**	
145-1	2/39	2*	3/33	3	1/37	1	2/20	4	4/11	5
145-2	0/3	1	1/13	2	8/37	3	12/41	4	21/24	5
145-3	9/33	3	10/56	2	2/47	1	7/19	4	2/2	5
Blanco	0/13	1	0/24	1	3/28	3	12/39	4	19/28	5
Totals	11/88 (12.5%)		14/126 (11.1%)		14/149 (9.4%)		33/119 (27.7%)		46/65 (70.8%)	

** Ranking assigned from 1 for class with lowest mortality rate to 5 for class with highest mortality rate.*

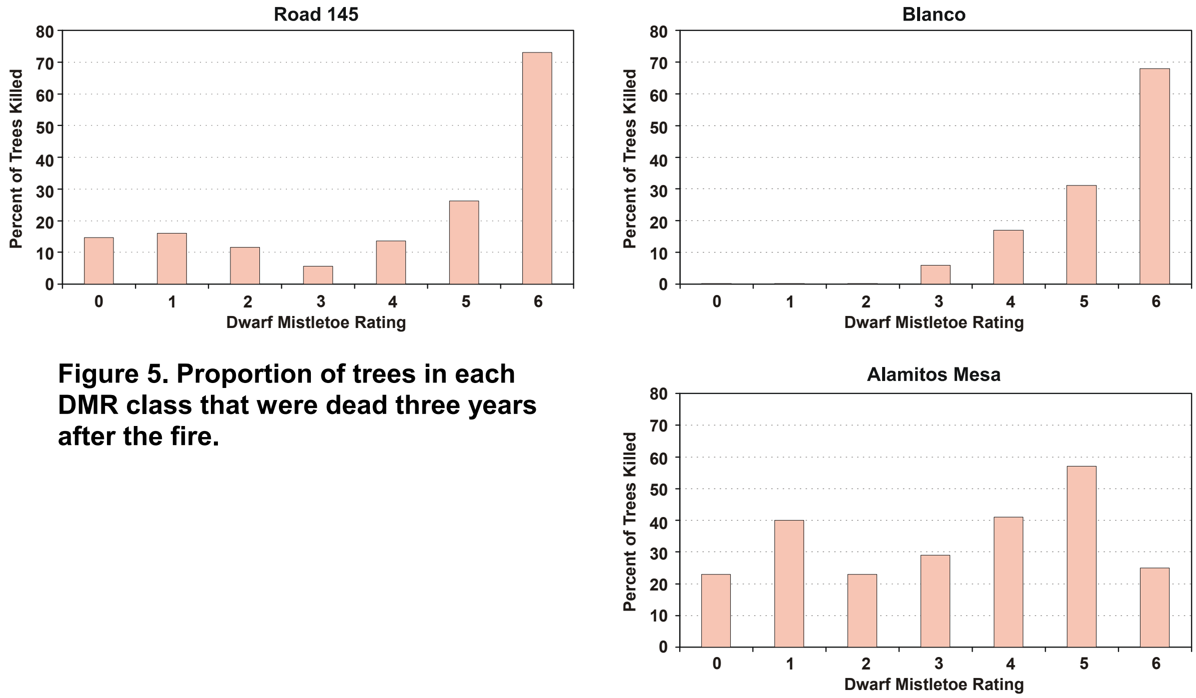


Figure 5. Proportion of trees in each DMR class that were dead three years after the fire.

Effect of Fire on Plot DMRs

Plot DMRs (the average DMR of all live trees on a plot) were reduced on each of the six plots. Reductions ranged from about 0.3 to 1.6, compared to projected values, three to four years after each fire (Figure 6). (Also, and more simply, each plot DMR was lower after the fire than before the fire, as Figure 6 indicates. However, the projections are needed to more fully account for effects of fire, given the inherent tendency of dwarf mistletoe to increase over time).

The greatest reduction (1.6) occurred in the Blanco fire, which was an early spring burn. However, this was probably more related to the particular stand and burning conditions than the season. Like most prescribed burns in the Southwest, each of these fires was conducted during the dormant season.

On the Road 145 and Blanco plots, reductions in plot DMR increased with increasing average scorch. On Alamitos Mesa, reductions were less, relative to scorch, than in the other fires. On all six plots, reductions occurred from a combination of tree mortality and scorch pruning. Scorch pruning will be discussed in more detail later.

The small reductions (relative to scorch) in the Alamitos burn were due, in part, to the random scorch pattern. Another factor was that the mechanical thinning had already lowered stand DMR considerably, limiting the potential for further reduction. Moreover, in a recently thinned stand the intensification of mistletoe is usually greater than in an unthinned stand. Greater intensification would have tended to offset measurable reductions from scorch. In fact, without the fire, the stand DMR probably would have increased at a greater rate than the projection shown in Figure 6.

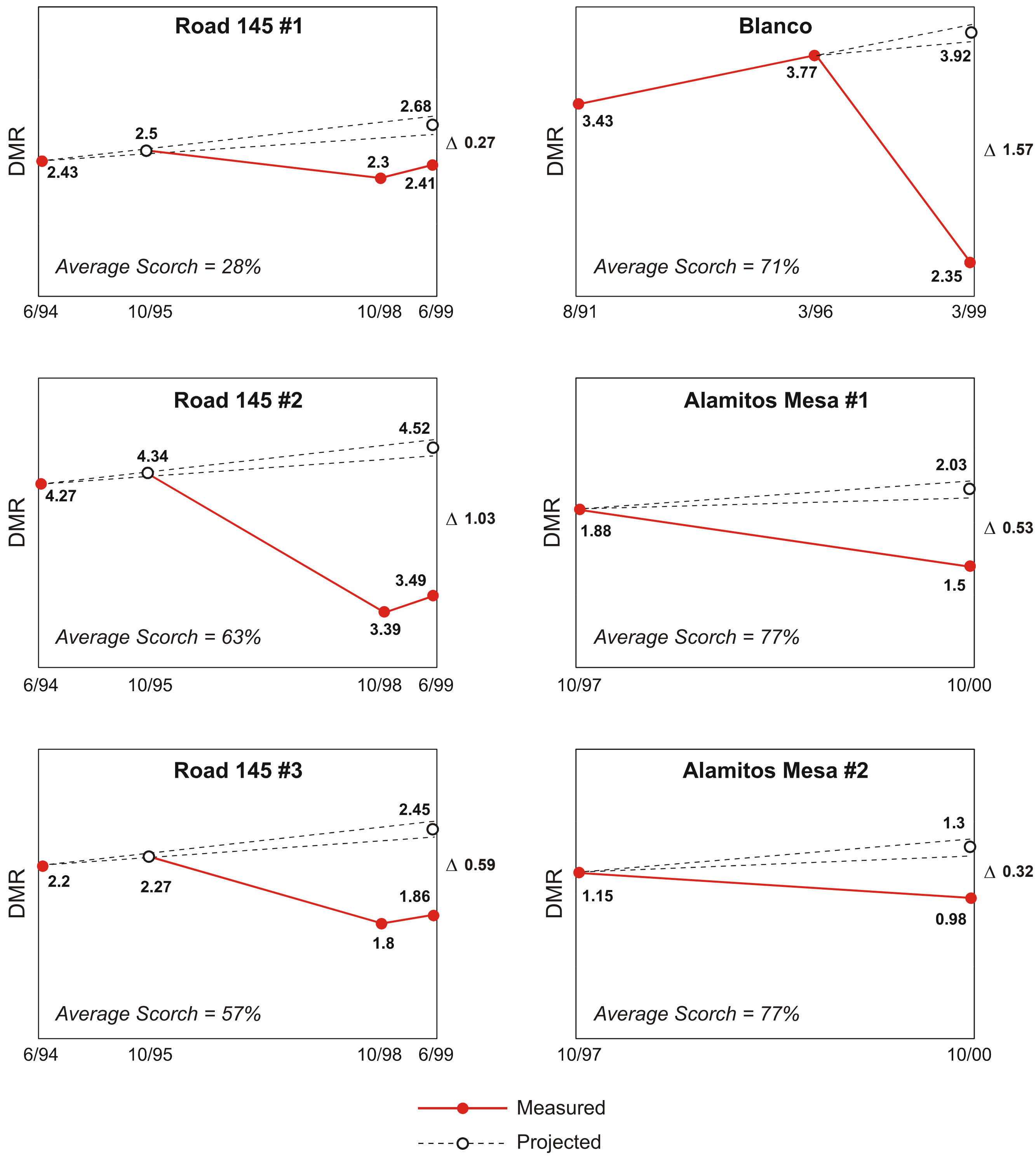


Figure 6. Changes in plot DMR's.

Projected values (dashed lines) are based on intensification rates on unburned plots (see Appendix A). For simplicity, a straight line connects the DMR at the burn date to its measured value 3 years later. A more realistic depiction would involve a steep drop at the burn date to some undetermined point, followed by a gradual rise to the measured value.

Effect of Fire on Percentage of Trees Infected

The percentage of trees visibly infected was also reduced on each plot (Table 3). Reductions occurred because infected trees (overall) had higher mortality rates than uninfected trees, and because some previously infected trees appeared to have been completely "sanitized" (see next section). Note that there were a few trees on each plot that were not visibly infected when the plots were set up, but were three years after the fire; in the absence of fire, the percentage of trees visibly infected, like plot DMR, would have increased.

Table 3. Change in percentage of trees (>4" dbh) visibly infected.

Plot	Pre-Fire	Post-Fire (3 yr)
145-1	72.1	68.0
145-2	97.4	92.1
145-3	77.0	66.9
Blanco	90.2	76.5
Alamitos-1	68.7	56.8
Alamitos-2	52.5	42.9

Scorch Pruning

Comparisons were made between the Road 145 plots and a set of similar unburned plots (see Appendix A) to compare changes in the ratings (DMRs) of surviving infected trees over five years (Figure 7). While there was no change on the majority of trees on either set of plots, on the burned plots a smaller proportion of trees had increases and a much greater proportion had decreases than on the unburned plots. Most, if not all of this difference in intensification was a result of fire-induced mortality of infected branches, i.e., scorch pruning.

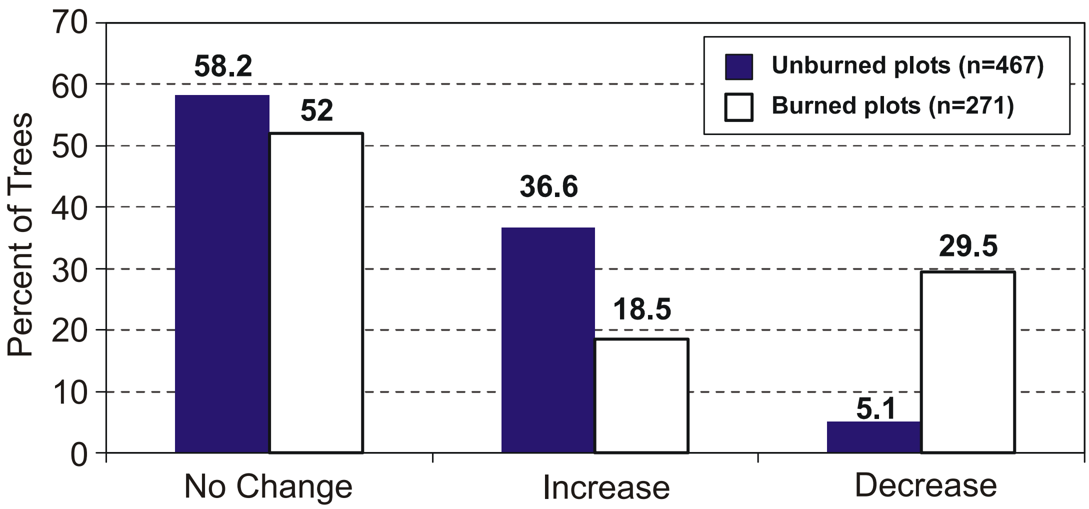


Figure 7. Change in DMR in five years on surviving infected trees.

Three years after the fires, 11 percent of the *previously infected, surviving trees* on the Road 145 plots, 13 percent of those on the Blanco plot, and 17 percent of those on the Alamitos plots, had no visible infection and received DMRs of 0.[6] (Trees were *not* rated 0 if they clearly had infections without shoots, particularly bole infections.) It is also likely that some recently infected trees not yet showing visible infection, i.e., having only latent infection, were sanitized by partial crown scorch.

The long-term effects of scorch pruning will undoubtedly vary from tree to tree. Death of infected branches will tend to improve growth and longevity, as well as reduce the spread of mistletoe. However, ratings (DMRs) are expected to rebound on many trees as the parasite continues its upward spread in the raised crowns. Nevertheless, scorch pruning may have set the parasite back on enough trees to make a difference in the development of these stands. Longer-term monitoring of these plots will help test these ideas.

Interactions of Scorch and Dwarf Mistletoe on Tree Mortality

Survival rates, by scorch class and DMR class, for all moderately and heavily scorched trees (> 4" dbh) in the three fires are presented in Table 4. Chi square tests of independence ($p < 0.01$) indicate that:

1. Survival rates among these three scorch classes are significantly different.
2. There is no significant difference in survival between DMR classes 0, 1-2, and 3-4 trees.
3. At moderate (40-80 percent) scorch, DMR 5 & 6 trees have significantly lower survival rates than DMR 0-4 trees.
4. At high (90-100 percent) scorch, only DMR 6 trees have significantly lower survival rates than other trees.

Table 4. Effects of mistletoe infection on survivability of scorched ponderosa pine (>4" dbh) in three prescribed fires in northern New Mexico; mortality determined three years after the fire.

Scorch	Dwarf Mistletoe Rating Class (DMR)				
Class	0	1-2	3-4	5	6
40-80%	57/60 (95%)	69/70 (99%)	78/81 (96%)	45/51 (88%)	16/19 (84%)
90%	33/43 (77%)	25/39 (64%)	23/28 (82%)	14/18 (78%)	1/6 (17%)
100%	9/27 (33%)	8/32 (25%)	14/40 (35%)	8/30 (27%)	0/38 (0%)

Dwarf mistletoe infection reduced the survival rates of scorched trees, but not to the extent reported by Harrington and Hawksworth (1990). In our study, infection reduced survival only for

[6] The number of trees completely “sanitized” was overestimated a few months after the fires because more of the scorched portions of the crown survived on most trees than expected. Only about half the trees that appeared to be fully sanitized at that time were free of visible infection three years after the fires.

heavily infected trees—DMR 5's and 6's. The effect was pronounced only for DMR 6 trees at 90 and 100 percent scorch. Among moderately scorched trees, heavy infection reduced survival significantly but not greatly; the survival rate of moderately scorched DMR 5 trees (88 percent) and DMR 6 trees (84 percent) was still high. Harrington and Hawksworth had indicated that a heavily infected tree with 50 percent crown scorch had less than half the probability of survival as an uninfected tree with 50 percent scorch.

Different stand conditions and burning seasons may explain some of the differences between the two studies. Their burn was conducted in August, prior to the onset of dormancy, which probably led to greater tree damage and mortality (Harrington 1987). Also, their plot contained many large, overmature trees which are less likely to recover from fire damage (Wagener 1961). None of the trees in their highest scorch class (88-100 percent) survived, while many trees within this range survived in each of our fires. Our results are probably more typical for dormant season burns in pole and small sawtimber-size stands.

Summary and Conclusions

These results confirm that underburns generating moderate to high levels of crown scorch have a strong tendency to reduce stand infection levels. Reductions of around 0.3 to 0.5 represent several years of stand growth before stand DMR returns to pre-burn levels. Reductions of 1.0 or more may represent 10-15 years or more of growth, depending on the post-burn intensification of dwarf mistletoe. The reductions achieved in any given burn will vary depending upon stand age and structure, distribution of fuels, burning conditions, ignition patterns, etc.

Longer-term monitoring will be needed to track the post-burn intensification of dwarf mistletoe. As mentioned, some "rebounding" of tree and stand DMR is expected. Each of these plots, along with several others established in more recent burns, will be remeasured within the next two years and periodically thereafter.

Underburning may be a good ecological approach for managing dwarf mistletoes on many ponderosa pine sites (and perhaps some mixed conifer sites) in the Southwest. On some sites, fire might be used to maintain infection at or below a desired level, allowing longer intervals between mechanical treatments. Periodic/repeat burning of infected stands should provide additional mistletoe reduction, depending upon stand age and how much the crowns were lifted by the initial burn.

In most situations, mistletoe reduction will probably not be the primary objective for a prescribed burn. However, the control that can be achieved through burning should be an important management consideration, given that dwarf mistletoe remains the most widespread and damaging disease in the forests of the Southwest. There is general agreement that decades of *fire exclusion* have been favorable to dwarf mistletoes. Fires producing an average crown scorch of 30 to 70 percent could potentially benefit the condition (health) of most mistletoe-infected ponderosa pine stands.

While some degree of control can be achieved through underburning, fire should not be regarded as a panacea in dwarf mistletoe management. In some areas, mechanical treatments are a more appropriate way to accomplish management objectives. In many areas, a combination of thinning and burning can be used to achieve an array of benefits.

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Appendices

A. Unburned Plots Used for Comparisons with Burned Plots

Plot Name, Location	Size in Acres	No. of Trees	Initial DMR	DMR 5 Years Later	Increase
Entranas, Camino Real RD, Carson NF	1.2	130	0.35	0.64	0.29
Jarita Mesa-1, El Rito RD, Carson NF	0.6	134	2.07	2.34	0.27
Jarita Mesa-2, El Rito RD, Carson NF	1.2	131	1.04	1.55	0.51
Mt. Taylor-1, Mt. Taylor RD, Cibola NF	1.4	145	1.54	1.88	0.34
Mt. Taylor-2, Mt. Taylor RD, Cibola NF	0.3	97	2.02	2.28	0.26
Mt. Taylor-3, Mt. Taylor RD, Cibola NF	0.8	132	0.66	0.73	0.07
La Jara, Camino Real RD, Carson NF	1.6	190	1.68	1.98	0.30

Dwarf mistletoe intensification measured on these unburned plots was used to develop the projections used in Figure 6. Both the average and median increase in plot DMR over the 5-year period was 0.29. A conservative figure of 0.25 (0.05 per year) was used as the projected intensification for each of the burned plots. These unburned plots were also used to compare changes in the ratings of surviving infected trees shown in Figure 7.

B. Diameter Growth of Scorched Trees

On the Road 145 plots, where diameter growth of the surviving scorched trees has been monitored for five years, it appears that significant reductions occurred only in the highest (90 and 100 percent) scorch classes; however, statistical tests have not yet been made. The monitoring period displayed here includes the majority of two growing seasons prior to the fire, which masks some of the differences.

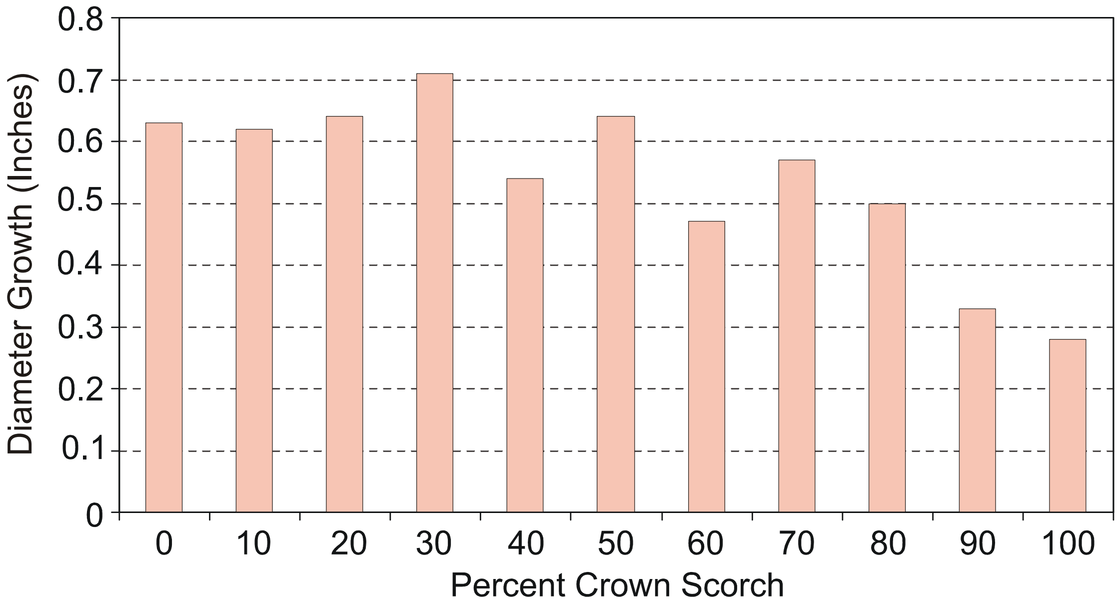

Figure 8. Diameter growth (5 year) by scorch class.

For trees with DMR 0 – 3 only, growth from 6/1994 to 6/1999, burned 10/1995.

C. Effects of Prescribed Fires on Dwarf Mistletoe Populations

On the Road 145 and Blanco plots, an attempt was made to quantify the effects of underburning on dwarf mistletoe populations. When the crown scorch ratings were done (a few months after each fire, prior to the flush of new growth), the proportion of the mistletoe plants killed (roots and all) on each sample tree was estimated to the nearest ten percent. The estimate was based on the proportion of plants well within the scorched portion of the crown, i.e., on branches that were expected to die. (Note that the large number of mistletoe plants on the plots made numerical counts impractical.)

A year or so later, it was apparent that the proportion of plants killed had been overestimated on most surviving trees because more of the scorched portion of the crowns recovered than expected. (In fact, because of bud survival, about *half* the scorched portion recovered on most surviving trees.) Observations indicated that the original estimates were typically about 40 percent high on the surviving infected trees. For example, an original estimate of 50 percent would have meant an actual reduction of about 30 percent (0.5 x 0.6).

Originally I had considered using the estimates, along with "weightings" based on tree size and DMR, to determine population reductions on each plot. However, with the above difficulties already compromising the results, plus the fact that new plants sprout each year, making it increasingly difficult to separate the original infections from the new ones, I decided to streamline the analysis (weigh all infected trees equally) and discontinue this portion of the study.

I calculated reductions in populations as follows: (Sum of estimates for surviving infected trees X 0.6)(number of surviving infected trees/total number of infected trees) + (number of dead infected trees/total number of infected trees). The very crude estimates are: Road 145-1: 42%; Road 145-2: 63%; Road 145-3: 51%; and Blanco: 67%.

Although not well quantified, reductions in populations were clearly higher, in relative terms, than reductions in plot DMR or the percentage of trees infected. This was expected, given that mistletoe plants tend to be concentrated in the lower portions of the crowns where they are most vulnerable to scorch.

It is unlikely that heat alone, in the absence of branch or tree mortality, has much effect on dwarf mistletoe. Koonce and Roth (1980) reported that shoots dried up following fires, setting back the life cycle. Although this may sometimes occur in the Southwest, it does not appear to be the usual pattern; shoots typically appear unaffected. Zimmerman and Laven (1987) found that dwarf mistletoe seed germination could be inhibited by smoke under laboratory conditions, but the significance of this to field conditions is unknown. In all likelihood, significant amounts of crown scorch are needed to have a reducing effect on dwarf mistletoe.